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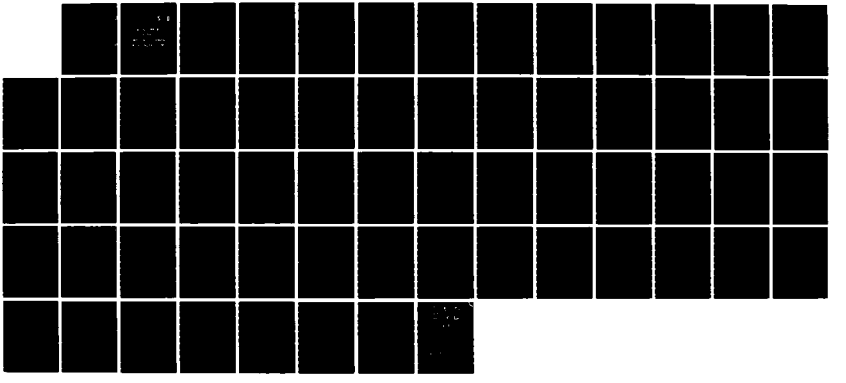

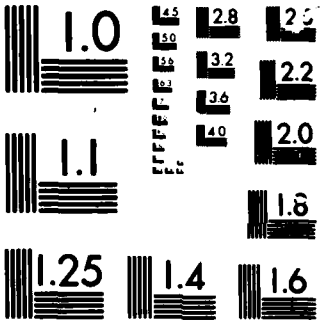
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RDA-TN-8502

PERCENT ERRORS IN THE ESTIMATION OF DEMAND FOR SECONDARY ITEMS

George Robinson
AMSMC-SAL
November 1985

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Percent Errors	Average Monthly Demand	Spares
Estimation	Wholesale Level	Commodity Command Standard System (CCSS)
Forecasting	Logistics	
Supply	Secondary Items	
Demand	Spare Parts	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

AMC subordinate commands use the Commodity Command Standard System (CCSS) to help manage secondary items. Percent errors in the estimation of demand are used by CCSS to compute economic order quantities and variable safety levels. Because the percent errors had not been verified for AMCCOM, this study computed percent errors from historical AMCCOM demand and return data. The percent errors found were roughly ten percent higher than the ones in use. It was recommended that the current percent errors be retained and that a limited number of serviceable returns be deducted from demand estimates.

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ACKNOWLEDGEMENTS

Significant guidance was received from Mr. Gordy Bergom of the AMCCOM Materiel Management Directorate. Messrs. Ed Gotwals and Alan Kaplan of the Inventory Research Office.

SUMMARY

Percent errors in the estimation of demand are used in the Commodity Command Standard System (CCSS) Economic Order Quantity/Variable Safety Level (EOQ/VSL) computations. The percent error is the average unsigned percentage difference between the estimated item demand and the actual demand. CCSS uses different percent errors for different demand levels and different item annual costs. These percent errors had never been verified at AMCCOM since the inception of CCSS during the 1970s.

Two related CCSS parameters also had never been verified:

1. The percentage of serviceable returned items used to offset demand, currently 20 percent.

2. The annual value of item demand used to classify items as low value or high value, currently $200 per year.

The following data were used to develop the percent errors in the estimation of demand:

1. Demand Return Disposal (DRD) transactions for the years 1979-1983.

2. National Item Identification Number (NIIN) changes.

3. The NIINs and other data for managed, non-ammunition items in CCSS.

The following method was used:

1. For each yearly file of DRD transactions the transaction count, quantity, and dollar value for each item were accumulated. Disposals, unserviceable returns, and the following demands were omitted:

   a. Non-recurring.

   b. One-time.

   c. Foreign military sales.

   d. Depot overhaul.

   e. Zero quantity.

2. After item NIINs were updated, the only items retained were those which met all six of the following criteria:

a. Managed.

b. Non-ammunition.

c. Non-provisioning.

d. Either Procurement Appropriation Secondary (PAS) or Army Stock Fund (ASF).

e. Normally stocked, stored, and issued.

f. Had nonzero demand in the first year of the study.

3. For each item, two years of demand history were used to predict the percent error for the following year. Percent errors were computed by comparing 1981-82 average demand level with 1983 net demand, i.e. demand less serviceable returns. Similarly 1980-81 was used to predict 1982, and 1979-80 to predict 1981.

4. Percent errors were accumulated by number of requisitions and yearly dollar value, and were adjusted to nine-month percent errors to accomodate CCSS.

Results and conclusions are as follows:

1. The computed percent errors were roughly ten percent higher than those in CCSS.

2. The current CCSS percent errors fit the observed distributions more closely than the computed percent errors did.

3. The expected number of requisitions generally exceeded the number observed in the past.

4. When serviceable returns were used to offset demands, the percent errors became larger.

5. When the low/high value breakpoint was increased from $200 to $500 or to $1,000, the percent errors changed very little, but the items became somewhat more equally divided between the low and high value classes.

6. By adjusting the means and the percent errors, better fits to the observed distributions were obtained.

It is recommended:

1. That the CCSS percent errors not be changed at present.

2. That serviceable returns not be used to offset demands.

3. That CCSS be revised to adjust the means before using the percent errors to compute the demand distribution.

If it appears feasible to revise CCSS to adjust the means, then it is recommended:

1. That the proposed breakpoint between low and high dollar value items be increased from $200 to some value between $500 and $1,000 per year.

2. That percent errors and factors to adjust the means be recomputed using the new breakpoint and the program change factors.

3. That the costs and benefits of adjusting the means and changing the percent errors be evaluated.

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INTRODUCTION

The Commodity Command Standard System (CCSS) is a computerized system that AMCCOM and other US Army commands use for materiel management. CCSS processes requisitions, keeps track of current items, records demand, return and disposal transactions, and determines reorder points, reorder quantities, and whether items should be stocked or ordered as needed.

The percent error is defined as the average unsigned percentage difference between the estimated item demand for a nine-month time span and the actual item demand for the nine months. For example, if the estimated demand is 100 and the actual demand is either 180 or 20, the percent error is 80 percent. Percent errors are provided by CCSS for seven levels of item annual demand and two levels of item annual total dollar value, <= $200.00 and $200.00. This methodology was developed by the US Army Inventory Research Office (IRO).

Percent errors in the estimation of demand are used in CCSS Economic Order Quantity/Variable Safety Level (EOQ/VSL) computations. The economic order quantity is the order quantity which is the least expensive in the long run. The variable safety level is the excess inventory carried to meet demand in excess of the estimates. CCSS EOQ/VSL computations use two years of demand history, the percent errors, and the program change factor (PCF) to predict item demand during the procurement leadtime (PROLT) for the item. The PCF accounts for the expected change in usage caused by changes in the type and number of weapon systems that use the item.

When this study was performed, CCSS did the EOQ/VSL computations only for nonprovisioning (old) items. (Currently, CCSS does the EOQ/VSL computations for provisioning items as well.) Provisioning items are denoted by a "4" in the third position of the Financial Inventory and Accounting Code (FIA-CD). Items usually change from provisioning to nonprovisioning status after two years in CCSS, but this change can be overridden.

DATA

The following data were used to develop the percent errors in the estimation of demand:

1. Demand Return Disposal (DRD) transactions for the years 1979-1983. The DRD transactions since 1976 are available on magnetic tape for all items, including ammunition items, nonmanaged items, and items which are no longer in CCSS.

2. National Item Identification Number (NIIN) changes were extracted from CCSS on 31 January 1984.

3. NIIN information for managed were non-ammunition items in CCSS, extracted 27 January 1984. The information included, for each item:

   a. The date that the item entered CCSS (DT-ENTRY).

   b. The Financial Inventory and Accounting Code (FIA-CD).

   c. The Inventory Management and Processing Code (IMPC).

METHOD

For each yearly file of DRD transactions the transaction count, quantity, and dollar value for each item were accumulated. The following transactions were omitted:

1. Disposals: Record Identification (REC-ID) = 3.

2. Unserviceable returns: REC-ID = 2 and Condition Code (COND-CD) not "A" through "E".

3. Transactions with zero quantity: Final Quantity (FNL-QTY) = 0.

4. Nonrecurring or one-time demands: Demand Code (DMD-CD) = "N" or "O".

5. Foreign military sales: the first character of Document Number (DOC-NO) = "B", and the sixth character of DOC-NO = "3" through "8" or "Z".

6. Depot overhaul demand: Project Code (PROJ-CD) = "ZCN".

After item NIINs were updated, only items which met all the following criteria were retained:

1. AMCCOM managed and non-ammunition: the first position of FIA-CD = "M".

2. Non-provisioning: the first two digits of DT-ENTRY were 80 or less. Although the FIA-CD identified items as provisioning or nonprovisioning, because the 1982 FIA-CDs were not available, the DT-ENTRY was used instead.

3. Either Procurement Appropriation Secondary (PAS) or Army Stock Fund (ASF). Note: All ASF items are secondary items.

   a. A PAS item has the second digit of the FIA-CD equal to "K" through "Z".

   b. An ASF item has the second digit of the FIA-CD equal to "2".

4. Stocked: IMPC = "1B" or "1C".

5. Demanded during the first year of the study, according to the DRD transactions. Note: This step insured that customer demand for the item had not just begun.

Demands could be offset by serviceable returns in either the predicting ("old") or predicted ("new") years. New year demand was offset by all of the new year serviceable returns, so that the accuracy of predicting the net new year demand would be found. Old year demand was offset by returns on a one-for-one basis, up to a given percentage of demand. Several maximum offsets were tested: 0 percent, 5 percent, 10 percent, 15 percent, 20 percent, 50 percent, and 100 percent of old year demand.

The deduction from predicted demand of a percentage of serviceable returns needs some explanation: Serviceable returns are items which were requisitioned and distributed to the field, not used, and subsequently returned. Therefore, serviceable returns indicate past demand, but there is no way to tell when that past demand occurred or what type of demand it was. It may have been demanded over two years ago or it may have been a non-recurring demand. Since CCSS only retains two years of demand history and because of the uncertainty of when past demand occurred or what type of demand it was, an adjustment to the recurring demand is made. Until recently a 5% offset was used. This offset has now been changed to 20% and may be revised again.

Percent errors were computed for each item and accumulated by demand level and item "extended price," that is, whether the average annual dollar value of the item was <= $200.00 or > $200.00 for the two predicting years. Percent errors were also accumulated for other extended price breakpoints, namely $100, $500, $1,000, $5,000, and $25,000. Old year demand was not offset by serviceable returns.

Because these computations found an average error for a 12-month time span but CCSS bases its percent errors on a 9-month span, each average percent error was then multiplied by the square root of 12/9, approximately 1.155. This method is the one used by CCSS, as documented in the CCSS Operating Instructions (CCSSOI) 18-710-102, Volume 4, Appendix C, as corrected by Mr. W. Karl Kruse of IRO.

Subsequently, percent errors were computed using demand during 1979-81 and 1980-82.

Histograms of the percent errors were computed so that the observed distributions could be compared with negative binomial distributions. For each item the computed ratio of actual demand to expected demand was tallied in the corresponding histogram cell. For each three year period two histograms were tallied, one for items with total annual value less than the $200 breakpoint and one for items exceeding the breakpoint. These histograms were then converted to show, for each level of annual demand, the percent of items in each class.

Moreover, the means and standard deviations were also

computed for items in each class of total annual value and average annual demand. The means and standard deviations were used to compute negative binomial distributions for comparison with:

1. The negative binomial distribution that CCSS would generate from the current ("old") percent errors.

2. The distribution that CCSS would generate from the computed ("new") percent errors.

3. The observed distribution. These comparisons were done cell by cell in the histograms by adding the unsigned differences between a negative binomial distribution and the observed distribution. Because the CCSS computation of safety levels involved only cases where the actual demand was higher than the predicted demand, only those cells were used in comparing the distributions.

In performing Chi-Square tests to compare distributions, all of the cells were used. However, if the expected value of a cell was five or less, that cell was combined with another cell. In each case the test was performed by first computing the Chi-Square value between two percent type histograms and then multiplying by the ratio of the number of items in the class divided by 100. Consequently the Chi-Square values are only approximate.

In order to obtain closer fits between the negative binomial and the observed demand distributions, different values of the mean and the standard deviation were tried. Closeness of fit was defined as the sum of the unsigned differences between the histogram cells where the demand exceeded the estimate. The sums of squares of those deviations were also computed.

In response to a suggestion by Mr. Ed Gotwals of IRO, an improved method of considering serviceable returns was developed. For this purpose, the percent error was computed from the ratio:

$$\frac{\text{prediction error}}{\text{old year demand}}$$

RESULTS

The percent errors for all years are tabulated in Appendix A. These percent errors were roughly ten percent higher than those in CCSS. The computed percent errors and those currently in CCSS are as follows:

Average Annual Number of Requisitions	Currently in CCSS		Computed	
	Annual Dollar Value		Annual Dollar Value	
	< = $200.	> $200.	< = $200.	> $200.
2.5 - 4	1.701	1.286	1.969	1.324
4.5 - 8	1.262	1.019	1.329	1.172
8.5 - 16	1.024	0.792	1.020	0.958
16.5 - 32	0.910	0.656	0.933	0.788
32.5 - 62	0.575	0.575	0.664	0.643
62.5 -122	0.469	0.469	0.578	0.558
122.5 and over	0.409	0.409	0.460	0.456

The percent errors for 1981-83 for different percentage offsets of old year serviceable returns are tabulated in Appendix B. The more that serviceable returns were used to help predict, the worse the predictions became. Consequently, serviceable returns were subsequently not used to predict future demands.

The percent errors for 1981-83 for different item annual cost breakpoints are tabulated in Appendix C. Because the results for other breakpoints were relatively close, the $200 breakpoint currently used in CCSS was chosen for use in the rest of the study. However, a $500 to $1,000 per year breakpoint would have given a more even split between the low and high dollar value items.

For general information, items with percent errors exceeding 1,000 percent are listed in Appendix D.

Percent error histograms are presented in Appendix E. By inspection, these histograms look somewhat like histograms for negative binomial distributions.

In appendix F, several negative binomial distributions are compared with each observed distribution. The column marked "Sum High Diffs" contains this sum for the region where the computation of safety levels would be affected, i.e., where the actual was higher than the predicted. In this region, the old

CCSS percent errors predicted markedly better than the new CCSS percent errors, and slightly better than direct computation for the known mean and standard deviation. In each case the negative binomial distributions resembled the observed one, even though Chi-Square tests usually showed that the observed distributions were not negative binomial.

Generally, CCSS underestimated the means and standard deviations of demand, as shown in Appendices G and H. By varying the means and standard deviations, closer fits to the observed demand distributions were obtained, as shown in an example in Appendix I.

Results of the improved method for considering serviceable returns are shown in Appendix J. The percent errors fell slightly, roughly three percent, as more serviceable returns were considered. The percent errors were generally the least when up to 20 to 50 percent of demand was offset with serviceable returns.

CONCLUSIONS

The principal conclusions from the above results are:

1. The computed percent errors were roughly ten percent higher than those in CCSS.

2. The current CCSS percent errors fit the observed distributions more closely than the computed percent errors did.

3. The expected number of requisitions differed from the number observed in the past.

4. When serviceable returns were used to offset demands, the accuracy of prediction improved.

5. When the low/high value breakpoint was increased from $200 to $500 and $1,000, the percent errors changed very little, and the items became somewhat more evenly distributed between the low and high value classes.

6. By adjusting the means and percent errors, better fits to the observed distributions were obtained.

Reservations include the following:

1. There is an uncertainty caused by not knowing the Program Chance Factor (PCF), which could be anywhere from 0.01 to 2.0 for non-provisioning items. This factor adjusts past demand to reflect changes in the number and location of weapon systems using the item. Since the PCF was not available, this adjustment was not made.

2. The percent errors found may be too low because some valid items without demands in the first year of three were excluded.

RECOMMENDATIONS

It is recommended:

1. That the CCSS percent errors not be changed at present.

2. That CCSS use serviceable returns to offset up to 20 to 50 percent of demands.

3. That CCSS be revised to adjust the means before using the percent errors to compute the demand distribution.

If it appears feasible to revise CCSS to adjust the means, then it is recommended:

1. That the proposed breakpoint between low and high dollar value items be increased from $200 to some value between $500 and $1,000 per year.

2. That percent errors and factors to adjust the means be recomputed using the new breakpoint and the program change factors.

3. That the costs and benefits of adjusting the means and changing the percent errors be evaluated.

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APPENDIX A

PERCENT ERRORS FOR ALL YEARS

PERCENT ERRORS FOR ALL YEARS

≤ $200 Per Year

Annual Requisitions	Currently in CCSS	1979-81	1980-82	1981-83	1-2-3 Weighted Average
2.5-4	1.701	1.682	1.984	2.055	1.969
4.5-8	1.262	1.297	1.238	1.400*	1.329
8.5-16	1.024	1.105	.991	1.010	1.020
16.5-32	.910	.901	.900*	.962	.931
32.5-62	.575	.703	.718	.616	.664
62.5-122	.469	.596*	.580*	.570*	.578
122.5 & Over	.409	.517*	.474*	.431*	.460

*Smoothed

> $200 Per Year

Annual Requisitions	Currently in CCSS	1979-81	1980-82	1981-83	1-2-3 Weighted Average
2.5-4	1.286	1.194	1.281	1.396	1.324
4.5-8	1.019	1.018	1.214	1.195	1.172
8.5-16	.792	.891	.960	.979	.958
16.5-32	.656	.753	.818	.779	.788
32.5-62	.575	.628	.641	.650*	.643
62.5-122	.469	.549	.550*	.566	.558
122.5 & Over	.409	.497	.474	.431	.456

*Smoothed

PERCENT ERRORS IN THE ESTIMATION OF DEMAND, FOR 1979-81

ALL DATA USED

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %
MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

BREAKPOINT = $ 200.00

AVERAGE ANNUAL NUMBER OF REQUISITIONS IN 1979-80	AVERAGE % ERRORS IN PREDICTIONS FOR 1981		
	AVERAGE % ERROR NET <= $ 200.00	AVERAGE % ERROR NET > $ 200.00	COMBINED AVERAGE % ERROR
0.5 - 2	2.644	1.486	2.391
2.5 - 4	1.682 *	1.194 *	1.486
4.5 - 8	1.297 *	1.018 *	1.133
8.5 - 16	1.105 *	0.891 *	0.953
16.5 - 32	0.901 *	0.753 *	0.782
32.5 - 62	0.703	0.628	0.637 *
62.5 - 122	1.313	0.549	0.596 *
122.5 and above	1.487	0.497	0.517 *

NOTES: Percent errors are given as decimals; for example, 1.000 denotes 100% error.

* denotes the items found in CCSSOI 18-710-102, Volume 4, Appendix C.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND, FOR 1980-82

ALL DATA USED

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %
MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

BREAKPOINT = $ 200.00

AVERAGE ANNUAL NUMBER OF REQUISITIONS IN 1980-81	AVERAGE % ERRORS IN PREDICTIONS FOR 1982		
	AVERAGE % ERROR NET <= $ 200.00	AVERAGE % ERROR NET > $ 200.00	COMBINED AVERAGE % ERROR
0.5 - 2	3.638	2.491	3.370
2.5 - 4	1.984 *	1.281 *	1.664
4.5 - 8	1.238 *	1.214 *	1.224
8.5 - 16	0.991 *	0.960 *	0.968
16.5 - 32	1.266 *	0.818 *	0.891
32.5 - 62	0.718	0.641	0.650 *
62.5 - 122	0.642	0.661	0.659 *
122.5 and above	0.411	0.474	0.473 *

NOTES: Percent errors are given as decimals; for example, 1.000 denotes 100% error.

* denotes the items found in CCSSOI 18-710-102, Volume 4, Appendix C.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND, FOR 1981-83

ALL DATA USED

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %
MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

BREAKPOINT = $ 200.00

AVERAGE ANNUAL NUMBER OF REQUISITIONS IN 1981-82	AVERAGE % ERRORS IN PREDICTIONS FOR 1983		
	AVERAGE % ERROR NET <= $ 200.00	AVERAGE % ERROR NET > $ 200.00	COMBINED AVERAGE % ERROR
0.5 - 2	7.508	3.067	6.336
2.5 - 4	2.055 *	1.396 *	1.741
4.5 - 8	2.276 *	1.195 *	1.614
8.5 - 16	1.010 *	0.979 *	0.987
16.5 - 32	0.962 *	0.779 *	0.805
32.5 - 62	0.616	0.768	0.753 *
62.5 - 122	0.647	0.566	0.570 *
122.5 and above	0.423	0.431	0.430 *

NOTES: Percent errors are given as decimals; for example, 1.000 denotes 100% error.

* denotes the items found in CCSSOI 18-710-102, Volume 4, Appendix C.

APPENDIX B

USING SERVICEABLE RETURNS TO OFFSET DEMANDS--PRELIMINARY

USING SERVICEABLE RETURNS TO OFFSET DEMANDS--PRELIMINARY

Combined Percent Errors (Both ≦ $200 and > $200)

Average Annual Number of Requisitions in 1981-82	Offset 0%	5%	10%	15%	20%	50%	100%
2.5-4	1.741	1.779	1.820	1.861	1.904	2.259	2.550
4.5-8	1.614	1.645	1.676	1.706	1.738	1.987	2.339
8.5-16	.987	1.007	1.026	1.045	1.066	1.214	1.470
16.5-32	.805	.821	.836	.852	.869	1.003	1.270
32.5-62	.753	.773	.793	.814	.838	1.025	.899
62.5-122	.570	.574	.579	.585	.594	.668	.924
122.5 & More	.430	.427	.427	.429	.433	.456	.471

APPENDIX C

PERCENT ERRORS FOR DIFFERENT BREAKPOINTS

PERCENT ERRORS FOR DIFFERENT BREAKPOINTS

Percent Errors for Annual Value ≦ Breakpoint

Average Annual Number of Requisitions in 1981-82	Breakpoint $100	$200	$500	$1000	$5000	$25000
2.5-4	2.295	2.055	1.867	1.799	1.740	1.746
4.5-8	2.694	2.276	1.967	1.833	1.680	1.630
8.5-16	1.068	1.010	1.001	1.023	1.009	.990
16.5-32	.997	.962	.847	.829	.813	.806
32.5-62	.573	.616	.582	.565	.816	.776
62.5-122	.834	.647	.605	.558	.595	.587
122.5 & More	.636	.423	.433	.348	.378	.421

Percent Errors for Annual Value > Breakpoint

Average Annual Number of Requisitions in 1981-82	Breakpoint $100	$200	$500	$1000	$5000	$25000
2.5-4	1.383	1.396	1.448	1.525	1.748	1.442
4.5-8	1.225	1.195	1.143	1.113	1.138	1.224
8.5-16	.973	.979	.976	.942	.888	.933
16.5-32	.789	.779	.788	.788	.787	.797
32.5-62	.763	.768	.796	.844	.644	.598
62.5-122	.566	.566	.564	.572	.538	.483
122.5 & More	.430	.431	.430	.436	.451	.446

NUMBER OF ITEMS BY CATEGORY FOR DIFFERENT BREAKPOINTS

FOR 1981-83

	Breakpoint					
	$100	$200	$500	$1000	$5000	$25000
Annual Value ≤ Breakpoint	1744	2583	3970	4959	7033	8340
Annual Value > Breakpoint	7378	6539	5152	4163	2089	782

APPENDIX D

ITEMS WITH PERCENT ERRORS EXCEEDING 1000 PERCENT

NIIN=004425696,	OLD.ANNUAL.REQNS=	55.5,	RATIO=103.8,	PREDICTED.QTY=	1976.0,	NET.NEW.QTY=	207138.0
NIIN=010035476,	OLD.ANNUAL.REQNS=	4.0,	RATIO= 70.4,	PREDICTED.QTY=	7.0,	NET.NEW.QTY=	500.0
NIIN=002353681,	OLD.ANNUAL.REQNS=	2.5,	RATIO= 62.2,	PREDICTED.QTY=	2.5,	NET.NEW.QTY=	158.0
NIIN=010443849,	OLD.ANNUAL.REQNS=	2.5,	RATIO= 59.2,	PREDICTED.QTY=	15.5,	NET.NEW.QTY=	933.0
NIIN=010443867,	OLD.ANNUAL.REQNS=	3.5,	RATIO= 53.4,	PREDICTED.QTY=	17.0,	NET.NEW.QTY=	925.0
NIIN=006586218,	OLD.ANNUAL.REQNS=	6.5,	RATIO= 52.0,	PREDICTED.QTY=	41.5,	NET.NEW.QTY=	2198.0
NIIN=010443870,	OLD.ANNUAL.REQNS=	5.0,	RATIO= 49.6,	PREDICTED.QTY=	18.0,	NET.NEW.QTY=	911.0
NIIN=010443863,	OLD.ANNUAL.REQNS=	5.0,	RATIO= 48.7,	PREDICTED.QTY=	18.0,	NET.NEW.QTY=	894.0
NIIN=010443484,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 45.9,	PREDICTED.QTY=	19.0,	NET.NEW.QTY=	891.0
NIIN=010443850,	OLD.ANNUAL.REQNS=	2.5,	RATIO= 40.6,	PREDICTED.QTY=	22.5,	NET.NEW.QTY=	935.0
NIIN=010438205,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 39.5,	PREDICTED.QTY=	22.0,	NET.NEW.QTY=	891.0
NIIN=010443862,	OLD.ANNUAL.REQNS=	4.0,	RATIO= 39.3,	PREDICTED.QTY=	22.0,	NET.NEW.QTY=	886.0
NIIN=010443869,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 36.7,	PREDICTED.QTY=	24.0,	NET.NEW.QTY=	904.0
NIIN=010443868,	OLD.ANNUAL.REQNS=	5.0,	RATIO= 35.5,	PREDICTED.QTY=	25.0,	NET.NEW.QTY=	912.0
NIIN=001794350,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 35.1,	PREDICTED.QTY=	7.5,	NET.NEW.QTY=	271.0
NIIN=010443864,	OLD.ANNUAL.REQNS=	5.0,	RATIO= 34.3,	PREDICTED.QTY=	25.0,	NET.NEW.QTY=	883.0
NIIN=010443865,	OLD.ANNUAL.REQNS=	6.5,	RATIO= 33.9,	PREDICTED.QTY=	26.5,	NET.NEW.QTY=	925.0
NIIN=010781274,	OLD.ANNUAL.REQNS=	3.0,	RATIO= 29.9,	PREDICTED.QTY=	11.5,	NET.NEW.QTY=	355.0
NIIN=008748703,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 29.8,	PREDICTED.QTY=	17.5,	NET.NEW.QTY=	539.0
NIIN=010443856,	OLD.ANNUAL.REQNS=	3.5,	RATIO= 28.4,	PREDICTED.QTY=	30.0,	NET.NEW.QTY=	883.0
NIIN=010350049,	OLD.ANNUAL.REQNS=	3.5,	RATIO= 27.8,	PREDICTED.QTY=	8.5,	NET.NEW.QTY=	245.0
NIIN=010443871,	OLD.ANNUAL.REQNS=	6.5,	RATIO= 27.4,	PREDICTED.QTY=	32.0,	NET.NEW.QTY=	909.0
NIIN=010815624,	OLD.ANNUAL.REQNS=	2.5,	RATIO= 26.6,	PREDICTED.QTY=	2.5,	NET.NEW.QTY=	69.0
NIIN=010437512,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 26.6,	PREDICTED.QTY=	13.5,	NET.NEW.QTY=	372.0
NIIN=010408806,	OLD.ANNUAL.REQNS=	7.5,	RATIO= 24.3,	PREDICTED.QTY=	8.0,	NET.NEW.QTY=	202.0
NIIN=006586227,	OLD.ANNUAL.REQNS=	5.5,	RATIO= 24.0,	PREDICTED.QTY=	43.5,	NET.NEW.QTY=	1087.0
NIIN=010420533,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 22.3,	PREDICTED.QTY=	7.0,	NET.NEW.QTY=	163.0
NIIN=010124704,	OLD.ANNUAL.REQNS=	7.0,	RATIO= 20.2,	PREDICTED.QTY=	12.0,	NET.NEW.QTY=	254.0
NIIN=010410426,	OLD.ANNUAL.REQNS=	5.5,	RATIO= 19.5,	PREDICTED.QTY=	13.0,	NET.NEW.QTY=	267.0
NIIN=010353687,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 19.0,	PREDICTED.QTY=	14.5,	NET.NEW.QTY=	290.0
NIIN=000930097,	OLD.ANNUAL.REQNS=	10.0,	RATIO= 18.9,	PREDICTED.QTY=	182.5,	NET.NEW.QTY=	3638.0
NIIN=010197124,	OLD.ANNUAL.REQNS=	3.5,	RATIO= 18.0,	PREDICTED.QTY=	4.0,	NET.NEW.QTY=	76.0
NIIN=010322332,	OLD.ANNUAL.REQNS=	11.0,	RATIO= 17.5,	PREDICTED.QTY=	44.0,	NET.NEW.QTY=	812.0
NIIN=010950297,	OLD.ANNUAL.REQNS=	17.5,	RATIO= 17.2,	PREDICTED.QTY=	130.5,	NET.NEW.QTY=	2372.0
NIIN=010659833,	OLD.ANNUAL.REQNS=	13.5,	RATIO= 17.1,	PREDICTED.QTY=	92.5,	NET.NEW.QTY=	1673.0
NIIN=010792959,	OLD.ANNUAL.REQNS=	2.5,	RATIO= 17.0,	PREDICTED.QTY=	3.5,	NET.NEW.QTY=	63.0
NIIN=010962402,	OLD.ANNUAL.REQNS=	4.5,	RATIO= 16.3,	PREDICTED.QTY=	7.0,	NET.NEW.QTY=	121.0
NIIN=010355607,	OLD.ANNUAL.REQNS=	5.0,	RATIO= 15.6,	PREDICTED.QTY=	8.5,	NET.NEW.QTY=	141.0
NIIN=010386022,	OLD.ANNUAL.REQNS=	3.0,	RATIO= 13.7,	PREDICTED.QTY=	5.5,	NET.NEW.QTY=	81.0
NIIN=009611311,	OLD.ANNUAL.REQNS=	3.0,	RATIO= 13.7,	PREDICTED.QTY=	42.0,	NET.NEW.QTY=	618.0

NIIN=010225323,	OLD.ANNUAL.REQNS=	3.5,	RATIO=	13.3,	PREDICTED.QTY=	4.0,	NET.NEW.QTY=	57.0
NIIN=010552788,	OLD.ANNUAL.REQNS=	3.5,	RATIO=	13.2,	PREDICTED.QTY=	4.5,	NET.NEW.QTY=	64.0
NIIN=002198161,	OLD.ANNUAL.REQNS=	4.5,	RATIO=	12.9,	PREDICTED.QTY=	7.5,	NET.NEW.QTY=	104.0
NIIN=000749507,	OLD.ANNUAL.REQNS=	5.5,	RATIO=	12.8,	PREDICTED.QTY=	12.0,	NET.NEW.QTY=	166.0
NIIN=009904384,	OLD.ANNUAL.REQNS=	2.5,	RATIO=	12.7,	PREDICTED.QTY=	3.5,	NET.NEW.QTY=	48.0
NIIN=010443916,	OLD.ANNUAL.REQNS=	6.5,	RATIO=	12.4,	PREDICTED.QTY=	38.0,	NET.NEW.QTY=	510.0
NIIN=010443840,	OLD.ANNUAL.REQNS=	4.5,	RATIO=	12.3,	PREDICTED.QTY=	10.0,	NET.NEW.QTY=	133.0
NIIN=009183006,	OLD.ANNUAL.REQNS=	15.5,	RATIO=	12.3,	PREDICTED.QTY=	28.0,	NET.NEW.QTY=	372.0
NIIN=010427989,	OLD.ANNUAL.REQNS=	11.0,	RATIO=	12.2,	PREDICTED.QTY=	18.0,	NET.NEW.QTY=	238.0
NIIN=010490155,	OLD.ANNUAL.REQNS=	6.0,	RATIO=	12.1,	PREDICTED.QTY=	11.0,	NET.NEW.QTY=	144.0
NIIN=008784195,	OLD.ANNUAL.REQNS=	4.0,	RATIO=	12.0,	PREDICTED.QTY=	9.0,	NET.NEW.QTY=	117.0
NIIN=010793031,	OLD.ANNUAL.REQNS=	4.0,	RATIO=	11.9,	PREDICTED.QTY=	8.5,	NET.NEW.QTY=	110.0
NIIN=010987708,	OLD.ANNUAL.REQNS=	7.5,	RATIO=	11.6,	PREDICTED.QTY=	10.5,	NET.NEW.QTY=	132.0
NIIN=000577168,	OLD.ANNUAL.REQNS=	4.5,	RATIO=	11.2,	PREDICTED.QTY=	28.5,	NET.NEW.QTY=	347.0
NIIN=010447097,	OLD.ANNUAL.REQNS=	3.0,	RATIO=	11.0,	PREDICTED.QTY=	13.0,	NET.NEW.QTY=	156.0
NIIN=010443843,	OLD.ANNUAL.REQNS=	5.0,	RATIO=	10.8,	PREDICTED.QTY=	5.5,	NET.NEW.QTY=	65.0
NIIN=010443861,	OLD.ANNUAL.REQNS=	2.5,	RATIO=	10.7,	PREDICTED.QTY=	3.5,	NET.NEW.QTY=	41.0
NIIN=010134229,	OLD.ANNUAL.REQNS=	5.0,	RATIO=	10.7,	PREDICTED.QTY=	26.0,	NET.NEW.QTY=	305.0
NIIN=004597288,	OLD.ANNUAL.REQNS=	5.5,	RATIO=	10.5,	PREDICTED.QTY=	9.5,	NET.NEW.QTY=	109.0
NIIN=004539377,	OLD.ANNUAL.REQNS=	3.5,	RATIO=	10.0,	PREDICTED.QTY=	10.5,	NET.NEW.QTY=	116.0

APPENDIX E

HISTOGRAMS OF PERCENT ERRORS

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1979-81, BY COUNT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST <= $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE	TOTAL COUNT: ALL CASES
0.5- 2	890	104	150	76	100	147	81	123	130	70	1871
2.5- 4	238	221	129	15	77	62	81	60	44	14	941
4.5- 8	85	166	122	13	69	74	57	50	23	7	666
8.5- 16	40	96	91	1	84	43	49	25	7	4	440
16.5- 32	19	42	58	0	36	22	29	9	3	0	218
32.5- 62	7	8	18	0	24	15	10	2	0	0	84
62.5-122	4	4	3	0	5	5	6	1	2	0	30
122.5 and more	0	0	3	0	1	0	3	3	0	0	10

Note: The number of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1979-81, BY COUNT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST > $200.00 PER YEAR

		ACTUAL WAS LOW			ACTUAL EQUALLED PREDICTION	ACTUAL WAS HIGH						TOTAL COUNT
		100%	99.99% TO 50.01%	50.00% TO 0.01%	0%	0.01% TO 50%	50.01% TO 100%	100.01% TO 200%	200.01% TO 400%	400.01% TO 1000%	1000.01% AND MORE	ALL CASES
AVERAGE ANNUAL REQUISITIONS	0.5- 2	243	55	57	30	37	30	21	26	17	7	523
	2.5- 4	175	166	89	21	48	40	41	30	18	2	630
	4.5- 8	219	231	188	14	123	66	58	34	18	1	952
	8.5- 16	195	272	257	9	137	86	75	35	7	2	1075
	16.5- 32	130	223	263	3	152	58	46	23	2	1	901
	32.5- 62	55	127	208	1	160	60	31	10	3	0	655
	62.5-122	23	76	161	0	126	39	24	5	0	0	454
	122.5 and more	7	29	156	1	190	65	37	6	0	0	491

Note: The number of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1979-81, BY PERCENT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST <= $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE
0.5- 2	48%	6%	8%	4%	5%	8%	4%	7%	7%	4%
2.5- 4	25%	23%	14%	2%	8%	7%	9%	6%	5%	1%
4.5- 8	13%	25%	18%	2%	10%	11%	9%	8%	3%	1%
8.5- 16	9%	22%	21%	0%	19%	10%	11%	6%	2%	1%
16.5- 32	9%	19%	27%	0%	17%	10%	13%	4%	1%	0%
32.5- 62	8%	10%	21%	0%	29%	18%	12%	2%	0%	0%
62.5-122	13%	13%	10%	0%	17%	17%	20%	3%	7%	0%
122.5 and more	0%	0%	30%	0%	10%	0%	30%	30%	0%	0%

Note: For each level of annual requisitions, the percent of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1979-81, BY PERCENT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST > $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW			ACTUAL EQUALLED PREDICTION	ACTUAL WAS HIGH					
	100%	99.99% TO 50.01%	50.00% TO 0.01%	0%	0.01% TO 50%	50.01% TO 100%	100.01% TO 200%	200.01% TO 400%	400.01% TO 1000%	1000.01% AND MORE
0.5- 2	46%	11%	11%	6%	7%	6%	4%	5%	3%	1%
2.5- 4	28%	26%	14%	3%	8%	6%	7%	5%	3%	0%
4.5- 8	23%	24%	20%	1%	13%	7%	6%	4%	2%	0%
8.5- 16	18%	25%	24%	1%	13%	8%	7%	3%	1%	0%
16.5- 32	14%	25%	29%	0%	17%	6%	5%	3%	0%	0%
32.5- 62	8%	19%	32%	0%	24%	9%	5%	2%	0%	0%
62.5-122	5%	17%	35%	0%	28%	9%	5%	1%	0%	0%
122.5 and more	1%	6%	32%	0%	39%	13%	8%	1%	0%	0%

Note: For each level of annual requisitions, the percent of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1980-82, BY COUNT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST <= $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE	TOTAL COUNT: ALL CASES
0.5- 2	907	115	161	94	107	181	121	172	163	123	2144
2.5- 4	183	162	114	18	98	78	102	68	56	17	896
4.5- 8	120	178	152	7	100	68	71	48	19	7	770
8.5- 16	34	92	100	3	68	45	34	21	8	1	406
16.5- 32	14	33	53	0	34	17	17	11	6	3	188
32.5- 62	1	8	31	0	26	16	7	4	1	0	94
62.5-122	0	1	7	0	14	7	4	1	0	0	34
122.5 and more	0	0	3	0	3	1	1	0	0	0	8

Note: The number of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1980-82, BY COUNT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST > $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE	TOTAL COUNT: ALL CASES
0.5- 2	232	49	69	37	43	50	36	64	55	18	653
2.5- 4	206	144	112	16	74	59	62	42	29	2	746
4.5- 8	234	240	199	13	135	100	93	71	23	5	1113
8.5- 16	155	288	293	4	173	106	77	29	9	6	1140
16.5- 32	92	227	291	5	165	86	63	28	9	1	967
32.5- 62	46	135	236	1	175	58	35	19	5	0	710
62.5-122	16	57	180	1	110	58	27	10	5	1	465
122.5 and more	12	22	161	0	232	74	27	11	0	0	539

Note: The number of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1980-82, BY PERCENT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST <= $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE
0.5- 2	42%	5%	8%	4%	5%	8%	6%	8%	8%	6%
2.5- 4	20%	18%	13%	2%	11%	9%	11%	8%	6%	2%
4.5- 8	16%	23%	20%	1%	13%	9%	9%	6%	2%	1%
8.5- 16	8%	23%	25%	1%	17%	11%	8%	5%	2%	0%
16.5- 32	7%	18%	28%	0%	18%	9%	9%	6%	3%	2%
32.5- 62	1%	9%	33%	0%	28%	17%	7%	4%	1%	0%
62.5-122	0%	3%	21%	0%	41%	21%	12%	3%	0%	0%
122.5 and more	0%	0%	38%	0%	38%	13%	13%	0%	0%	0%

Note: For each level of annual requisitions, the percent of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1980-82, BY PERCENT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST > $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	99.99% TO 50.01%	50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	50.01% TO 100%	100.01% TO 200%	200.01% TO 400%	400.01% TO 1000%	1000.01% AND MORE
0.5- 2	36%	8%	11%	6%	7%	8%	6%	10%	8%	3%
2.5- 4	28%	19%	15%	2%	10%	8%	8%	6%	4%	0%
4.5- 8	21%	22%	18%	1%	12%	9%	8%	6%	2%	0%
8.5- 16	14%	25%	26%	0%	15%	9%	7%	3%	1%	1%
16.5- 32	10%	23%	30%	1%	17%	9%	7%	3%	1%	0%
32.5- 62	6%	19%	33%	0%	25%	8%	5%	3%	1%	0%
62.5-122	3%	12%	39%	0%	24%	12%	6%	2%	1%	0%
122.5 and more	2%	4%	30%	0%	43%	14%	5%	2%	0%	0%

Note: For each level of annual requisitions, the percent of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1981-83, BY COUNT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST <= $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE	TOTAL COUNT: ALL CASES
0.5- 2	780	137	149	81	106	139	121	167	129	128	1937
2.5- 4	224	176	143	20	113	90	107	104	65	19	1061
4.5- 8	116	155	141	7	96	73	80	65	46	26	805
8.5- 16	36	88	103	1	67	54	42	24	9	0	424
16.5- 32	13	27	46	0	44	16	16	11	2	1	176
32.5- 62	4	14	25	0	22	9	8	1	0	0	83
62.5-122	0	3	12	0	7	4	0	2	0	0	28
122.5 and more	0	0	1	0	2	3	0	0	0	0	6

Note: The number of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1981-83, BY COUNT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST > $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE	TOTAL COUNT: ALL CASES
0.5- 2	257	48	78	23	60	64	41	60	42	22	695
2.5- 4	258	161	147	21	106	80	83	66	44	3	969
4.5- 8	259	302	211	15	173	104	91	81	31	5	1272
8.5- 16	198	343	295	13	214	114	89	47	26	5	1344
16.5- 32	122	264	296	6	178	80	72	26	7	0	1051
32.5- 62	50	174	256	3	168	72	39	13	0	1	776
62.5-122	32	104	225	0	93	53	20	5	1	0	533
122.5 and more	29	75	329	0	126	22	5	6	2	0	594

Note: The number of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1981-83, BY PERCENT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST <= $200.00 PER YEAR

AVERAGE ANNUAL REQUISITIONS	ACTUAL WAS LOW: 100%	ACTUAL WAS LOW: 99.99% TO 50.01%	ACTUAL WAS LOW: 50.00% TO 0.01%	ACTUAL EQUALLED PREDICTION: 0%	ACTUAL WAS HIGH: 0.01% TO 50%	ACTUAL WAS HIGH: 50.01% TO 100%	ACTUAL WAS HIGH: 100.01% TO 200%	ACTUAL WAS HIGH: 200.01% TO 400%	ACTUAL WAS HIGH: 400.01% TO 1000%	ACTUAL WAS HIGH: 1000.01% AND MORE
0.5- 2	40%	7%	8%	4%	5%	7%	6%	9%	7%	7%
2.5- 4	21%	17%	13%	2%	11%	8%	10%	10%	6%	2%
4.5- 8	14%	19%	18%	1%	12%	9%	10%	8%	6%	3%
8.5- 16	8%	21%	24%	0%	16%	13%	10%	6%	2%	0%
16.5- 32	7%	15%	26%	0%	25%	9%	9%	6%	1%	1%
32.5- 62	5%	17%	30%	0%	27%	11%	10%	1%	0%	0%
62.5-122	0%	11%	43%	0%	25%	14%	0%	7%	0%	0%
122.5 and more	0%	0%	17%	0%	33%	50%	0%	0%	0%	0%

Note: For each level of annual requisitions, the percent of items in each class is shown.

PERCENT ERRORS IN THE ESTIMATION OF DEMAND -- HISTOGRAM FOR 1981-83, BY PERCENT

MAXIMUM OLD YEAR DEMAND OFFSET = 0.00 %

MAXIMUM NEW YEAR DEMAND OFFSET = 100.00 %

ITEM ANNUAL COST > $200.00 PER YEAR

		ACTUAL WAS LOW			ACTUAL EQUALLED PREDICTION	ACTUAL WAS HIGH					
		100%	99.99% TO 50.01%	50.00% TO 0.01%	0%	0.01% TO 50%	50.01% TO 100%	100.01% TO 200%	200.01% TO 400%	400.01% TO 1000%	1000.01% AND MORE
AVERAGE ANNUAL REQUISITIONS	0.5- 2	37%	7%	11%	3%	9%	9%	6%	9%	6%	3%
	2.5- 4	27%	17%	15%	2%	11%	8%	9%	7%	5%	0%
	4.5- 8	20%	24%	17%	1%	14%	8%	7%	6%	2%	0%
	8.5- 16	15%	26%	22%	1%	16%	8%	7%	3%	2%	0%
	16.5- 32	12%	25%	28%	1%	17%	8%	7%	2%	1%	0%
	32.5- 62	6%	22%	33%	0%	22%	9%	5%	2%	0%	0%
	62.5-122	6%	20%	42%	0%	17%	10%	4%	1%	0%	0%
	122.5 and more	5%	13%	55%	0%	21%	4%	1%	1%	0%	0%

Note: For each level of annual requisitions, the percent of items in each class is shown.

APPENDIX F

THE NEGATIVE BINOMIAL DISTRIBUTION

The Negative Binomial Distribution

The negative binomial distribution is used by CCSS to estimate the quantity of demands for an item. This distribution is discrete and unimodal, and as the variance approaches the mean it becomes Poisson.

This distribution can be computed from its mean μ and standard deviation σ as follows:

$$p = \frac{\mu}{\sigma^2}$$

$$q = 1 - p$$

$$r = \frac{\mu - p}{q}$$

Let ρ_k denote the probability density at each nonnegative integer k. Then

$$\rho_0 = p^r$$

and for $k > 0$,

$$\rho_k = \rho_{k-1} \times \frac{q \times (k + r - 1)}{k}$$

For computational purposes we assume that all requisitions for an item are for the same quantity of items.

Source: Alan Kaplan of the US Army Inventory Research Office (IRO), by telephone on 9 September 1983.

In Tables F-1 and F-2, theoretical and observed distributions are tabulated together for comparison. The distributions are of four types:

1. Old CCSS -- figured from the current CCSS percent errors, as CCSS would: the mean was the average demand during the past two years, and the standard deviation was computed from the mean and the percent errors.

2. New CCSS -- figured from the computed percent errors as CCSS would.

3. Direct -- figured directly from the observed mean and standard deviation for 1981-1983.

4. Observed -- observed for 1981-1983.

Because the distributions are rounded to the nearest percent, they sometimes do not add up to 100 percent. Because of outliers in the data, the mean and standard deviation for two distributions were not readily available. Two other distributions were omitted because they had only 6 and 28 data points respectively.

The numerical column headings need some further explanation, since only one limit for each column is given. For example, the column titled "> 50%" includes only items with percent errors > 50 percent and < 100 percent, and the column titled "$\leq$ 1000%" includes only items with percent errors > 400 percent and $\leq$ 1000 percent.

The "Sum High Diffs" column compares the theoretical distributions with the observed ones. Because we are primarily concerned with safety level, the distributions were compared only for the cases when they exceeded their means. For these cases for each theoretical distribution, the absolute values of the deviations from the observed percentages were added and placed in the Sum High Diffs column. Consequently, the smaller the Sum High Diffs value, the better the fit of the theoretical distribution to the observed one.

When the Old and New CCSS distributions were compared, the old one fit more closely. In only twelve cases were there sufficient items for a valid comparison. In seven cases, the Old CCSS distribution fit more closely; in one case, the New CCSS distribution fit more closely; and in four cases, the two distributions fit equally closely.

In Tables F-3 and F-4 the results of chi-squared tests comparing the various distributions are presented. The columns labeled "Reject 10%" and "Reject 1%" give the values of the chi-squared statistic above which we assert with 90 percent and 99 percent confidence, respectively, that the data was not distributed according to the test distribution.

Table F-1

Distributions for Annual Value ≤ $200

Annual Requisitions	Type Distribution	Actual Was Low			Okay	Actual Was High						Sum High Diffs
		100%	>50%	>0%	0%	≤50%	≤100%	≤200%	≤400%	≤1000%	>1000%	
2.5 to 4	Old CCSS	56	11	6	4	3	5	4	5	4	1	25
	New CCSS	64	9	5	3	2	4	3	4	4	2	28
	Direct	53	9	5	4	3	4	4	5	7	5	27
	Observed	21	17	13	2	11	8	10	10	6	2	
4.5 to 8	Old CCSS	34	20	15	3	7	5	6	6	3	0	21
	New CCSS	39	19	13	3	6	4	6	5	4	0	23
	Direct											
	Observed	14	19	18	1	12	9	10	8	6	3	
8.5 to 16	Old CCSS	14	31	20	2	11	7	8	5	2	0	14
	New CCSS	13	31	20	2	11	7	8	5	2	0	14
	Direct	7	26	21	3	13	9	11	8	2	0	10
	Observed	8	21	24	0	16	13	10	6	2	0	
16.5 to 32	Old CCSS	6	36	22	1	12	8	8	5	1	0	17
	New CCSS	8	36	21	1	12	8	8	5	1	0	17
	Direct	8	31	16	1	11	8	10	8	4	0	22
	Observed	7	15	26	0	25	9	9	6	1	1	
32.5 to 62	Old CCSS	0	26	32	1	20	11	7	2	0	0	11
	New CCSS	0	28	31	1	19	11	8	2	0	0	11
	Direct	0	23	32	1	21	12	8	2	0	0	10
	Observed	5	17	30	0	27	11	10	1	0	0	
62.5 to 122	Old CCSS	0	19	38	1	25	11	5	1	0	0	
	New CCSS	0	26	33	1	21	11	7	2	0	0	Only 28 Items
	Direct											
	Observed	0	11	43	0	25	14	0	7	0	0	
122.5 and Over	Old CCSS	0	14	42	0	28	11	4	0	0	0	
	New CCSS	0	16	41	0	27	11	5	0	0	0	Only 6 Items
	Direct											
	Observed	0	0	17	0	33	50	0	0	0	0	

Table F-2

Distributions for Annual Value > $200

Annual Requisitions	Type of Distribution	Actual Was Low			Okay	Actual Was High						Sum High Diffs
		100%	>50%	>0%	0%	≤50%	≤100%	≤200%	≤400%	≤1000%	>1000%	
2.5 to 4	Old CCSS	43	15	9	6	5	7	6	5	3	0	14
	New CCSS	47	14	8	6	4	6	6	5	4	0	15
	Direct	36	14	9	7	5	8	7	7	5	1	9
	Observed	27	17	15	2	11	8	9	7	5	0	
4.5 to 8	Old CCSS	20	23	20	5	11	7	8	5	2	0	6
	New CCSS	31	21	16	4	8	5	7	6	3	0	10
	Direct	34	19	13	3	7	5	6	6	5	1	15
	Observed	20	24	17	1	14	8	7	6	2	0	
8.5 to 16	Old CCSS	6	29	25	3	15	9	8	4	1	0	5
	New CCSS	12	31	20	2	12	7	8	5	1	0	9
	Direct	19	30	16	2	9	6	9	6	3	0	15
	Observed	15	26	22	1	16	8	7	3	2	0	
16.5 to 32	Old CCSS	1	28	30	2	18	10	8	3	0	0	6
	New CCSS	3	33	25	2	15	9	8	4	0	0	7
	Direct	4	36	25	2	14	8	7	3	0	0	5
	Observed	12	25	26	1	17	8	7	2	1	0	
32.5 to 62	Old CCSS	0	26	32	1	20	11	7	2	0	0	6
	New CCSS	0	30	29	1	18	10	8	2	0	0	8
	Direct											
	Observed	6	22	33	0	22	9	5	2	0	0	
62.5 to 122	Old CCSS	0	19	38	1	25	11	5	1	0	0	10
	New CCSS	0	26	33	1	21	11	7	2	0	0	9
	Direct	0	33	32	1	18	9	6	1	0	0	4
	Observed	6	20	42	0	17	10	4	1	0	0	
122.5 and Over	Old CCSS	0	14	42	0	28	11	4	0	0	0	18
	New CCSS	0	16	41	0	27	11	5	0	0	0	18
	Direct	0	31	37	0	19	8	4	0	0	0	10
	Observed	5	13	55	0	21	4	1	1	0	0	

TABLE F-3

CHI-SQUARE TESTS

TOTAL VALUE $\leq$ $200/YEAR

Annual Reqns	Type of Distribution	Degrees of Freedom	Approximate Chi-Square Statistic	Reject 10%	Reject 1%
2.5	New CCSS	9	1273	14.68	21.67
to 4	Direct	7	865	12.02	18.48
4.5	New CCSS	8	464	13.36	20.09
to 8	Direct	-	-	-	-
8.5	New CCSS	8	68	13.36	20.09
to 16	Direct	6	32	10.64	16.81
16.5	New CCSS	6	49	10.64	16.81
to 32	Direct	5	54	9.236	15.09
32.5	New CCSS	4	4.8	7.779	13.28
to 62	Direct	2	1.8	4.605	9.210
62.5	New CCSS	3	33	6.251	11.34
to 122	Direct	-	-	-	-
122.5	New CCSS	-	-	-	-
and Over	Direct	-	-	-	-

TABLE F-4

CHI-SQUARE TESTS

TOTAL VALUE >$200/YEAR

Annual Reqns	Type of Distribution	Degrees of Freedom	Approximate Chi-Square Statistic	Reject 10%	Reject 1%
2.5	New CCSS	8	375	13.36	20.09
to 4	Direct	6	148	10.64	16.81
4.5	New CCSS	8	169	13.36	20.09
to 8	Direct	6	271	10.64	16.81
8.5	New CCSS	7	54	12.02	18.48
to 16	Direct	6	168	10.64	16.81
16.5	New CCSS	7	321	12.02	18.48
to 32	Direct	5	219	9.236	15.09
32.5	New CCSS	5	20	9.236	15.09
to 62	Direct	-	-	-	-
62.5	New CCSS	5	24	9.236	15.09
to 122	Direct	2	25	4.605	9.210
122.5	New CCSS	4	57	7.779	13.28
and Over	Direct	2	103	4.605	9.210

APPENDIX G

EXPECTED AND ACTUAL MEAN

EXPECTED AND ACTUAL MEAN

Item Annual Cost $\leq$ $200 per year

Average Annual Number of Requisitions	Ratio of Actual Mean to Expected Mean 1979-81	1980-82	1981-83
2.5 - 4	1.514	1.972	2.044
4.5 - 8	1.407	1.302	2.295
8.5 - 16	1.347	1.217	1.280
16.5 - 32	1.186	1.548	1.347
32.5 - 62	1.207	1.327	1.051
62.5 - 122	1.640	1.406	1.202
122.5 and more	2.127	1.255	1.299

Item Annual Cost > $200 per year

Average Annual Number of Requisitions	Ratio of Actual Mean to Expected Mean 1979-81	1980-82	1981-83
2.5 - 4	1.008	1.185	1.338
4.5 - 8	.948	1.205	1.177
8.5 - 16	.906	1.050	1.063
16.5 - 32	.849	1.022	.917
32.5 - 62	.947	.997	1.057
62.5 - 122	.989	1.151	.896
122.5 and more	1.196	1.183	.853

APPENDIX H

EXPECTED AND ACTUAL STANDARD DEVIATION

EXPECTED AND ACTUAL STANDARD DEVIATION

Item Annual Cost $\leq$ $200 per year

Average Annual Number of Requisitions	Ratio of Actual to Expected Standard Deviation 1979-81	1980-82	1981-83
2.5 - 4	1.671	1.830	1.806
4.5 - 8	1.143	1.233	2.900
8.5 - 16	1.393	1.211	1.110
16.5 - 32	.983	2.116	1.435
32.5 - 62	1.769	1.223	.959
62.5 - 122	2.289	.882	1.350
122.5 and more	1.920	.931	.686

Item Annual Cost > $200 per year

Average Annual Number of Requisitions	Ratio of Actual to Expected Standard Deviation 1979-81	1980-82	1981-83
2.5 - 4	1.098	1.081	1.157
4.5 - 8	1.295	1.509	1.298
8.5 - 16	1.102	1.976	1.280
16.5 - 32	1.004	1.807	.976
32.5 - 62	.992	1.081	4.776
62.5 - 122	.955	1.723	.986
122.5 and more	.966	1.004	1.080

COMPUTING THE STANDARD DEVIATION

Glossary:

PCER is the percent error in demand for a nine month period.
PCER-LT is percent error in the procurement lead time.
PROLT is procurement lead time in months.
PROLT-DMD is the demand during the PROLT.
AMD is average monthly demand.
STD-DEV is the standard deviation.
AYD is average yearly demand.

The CCSS Computation:

1. Source: CCSS Operating Instructions 18-710-102, Volume 4, Appendix C, as corrected by Karl Kruse of the Inventory Research Office.

2. Compute PCER-LT = PCER/ (PROLT/9) **0.5

3. Compute PROLT-DMD = AMD x PROLT

4. If PROLT-DMD > 20 use GAMMA = 1.41; otherwise use GAMMA from this table:

PCER-LT	GAMMA
0 to .5	1.27
Over .5 to .8	1.33
Over .8 to 1.0	1.42
Over 1.0	1.52

5. Compute STD-DEV = PROLT-DMD x GAMMA x PCER-LT

Our Computation:

1. Compute PCER-LT as in the CCSS computation. To generate a distribution comparable to the twelve-month histograms in Appendix E, PROLT = 12 months was used.

2. Compute the AYD as follows.

a. For each interval of annual requisitions, choose a representative to generate a typical distribution for the interval. The numbers chosen were 3, 6, 12, 22, 45, 85, and 175 requisitions per year.

b. For each interval, compute AYD = Annual Requisitions x Average Quantity Requisitioned, using 2 as the Average Quantity Requisitioned.

3. Compute PROLT-DMD = AYD x PROLT in years. PROLT in years = 1.0.

4. Compute GAMMA as in the CCSS computation. For 3 and 6 annual requisitions, PROLT-DMD = 6 and 12 respectively; since PCER-LT > 1.0, GAMMA = 1.52. For 12 and more annual requisitions, PROLT-DMD > 20, so GAMMA = 1.41.

5. Compute STD-DEV as in the CCSS computation.

APPENDIX I

OBTAINING CLOSER FITS TO THE DEMAND DISTRIBUTIONS

In Table I-1 closer fits to an observed demand distribution were obtained by varying the mean and standard deviation of negative binomial distributions. This case involved 2.5 to 4 annual requisitions with an annual value of $200 or less.

The columns of Table I-1 are as follows:

1. The distribution used.

2. Actual Low or Equal: The percent of cases with the observed value less than or equal to the mean.

3. Actual was High: The percent of cases with the observed value greater that the mean, further subdivided into a histogram as follows:

   a. $\leq$ 50% denotes cases with the observed value up to 1.5 times the mean.

   b. $\leq$ 100% denotes cases with the observed value between 1.5 and 2 times the mean.

   c. Similarly, $\leq$ 200%, $\leq$ 400%, and $\leq$ 1000% denote observed values from 2 to 3 times, from 3 to 5 times, and from 5 to 11 times the mean.

   d. $>$ 1000% denotes that demand was more than 11 times the mean.

4. Sum Pos Diffs: For cases when the actual exceeded the mean, the sum of the percent differences between the observed and test distributions.

5. Sum Pos Diffs^2: The sum of the squares of those differences.

The rows of Table I-1 are as follows:

1. Observed--The histogram observed when using 1981-82 to predict 1983.

2. Old CCSS--Using the current CCSS percent error with mean = 3 and standard deviation = 6.717.

3. New CCSS--Using the computed CCSS percent error with mean = 3 and standard deviation = 8.117.

4. Direct--Using the computed mean and computed standard deviation.

5. Variations of old and new CCSS with μ=3--One of these distributions could be used without revising CCSS but by changing only the percent errors now in CCSS.

6. Variations of direct with μ = 6.132 --Possibilities by using the expected mean and various standard deviations. Use of one of these distributions would require a revision of CCSS.

7. Variations of direct--Possibilities by using various means and standard devitions. Use of one of these distributions would also require a revision of CCSS.

TABLE I-1

Obtaining Closer Fits to the Demand Distributions

Total Value $\leq$ \$200/yr. 2.5 to 4 Annual Reqns.	Actual Low or equal	Actual was High						Sum High Diffs	Sum High Diffs^2
		$\leq$ 50%	$\leq$ 100%	$\leq$ 200%	$\leq$ 400%	$\leq$ 1000%	> 1000%		
Observed	53	11	8	10	10	6	2		
Old CCSS μ =3, σ = 6.717	78	3	5	4	5	4	1	25	139
New CCSS μ =3, σ = 8.117	81	2	4	3	4	4	2	28	186
Direct μ =6.132, σ =14.655	71	3	4	4	5	7	5	27	151
Variations of old and new CCSS with μ = 3									
σ = 2	65	15	15	5	0	0	0	34	230
σ = 3	66	9	12	8	4	0	0	22	100
σ = 4	70	7	9	7	5	2	0	19	71
σ = 5	73	5	7	6	6	3	0	20	82
σ = 6	76	4	5	5	5	4	0	24	116
σ = 8	81	3	4	4	4	4	2	26	156
σ = 10	84	2	3	3	3	4	2	30	208
Variations of direct with μ = 6.132									
σ = 6	42	8	14	14	14	7	0	20	82
σ = 8	52	6	10	10	11	10	1	13	47
σ = 9	56	6	8	9	10	9	2	9	35
σ = 10	59	5	7	8	9	9	3	14	52
σ = 12	65	4	6	6	7	8	4	20	86
σ = 16	73	3	4	4	5	7	5	27	151
σ = 20	79	2	3	3	3	5	5	32	214
Variations of direct									
μ = 4.5, σ = 4.5	53	9	14	12	9	3	0	16	58
σ = 6	60	7	10	9	9	5	0	11	27
σ = 7.5	65	5	7	7	8	6	1	13	51
μ = 8, σ = 8	35	7	12	14	17	13	1	27	147
σ = 10	44	6	10	11	13	13	3	19	89
σ = 12	51	5	8	9	11	12	5	17	83

Note: μ = mean, σ = standard deviation

Also note: The Sum High Diffs and Sum High Diffs^2 columns include only cases where the actual was high.

APPENDIX J

USING SERVICEABLE RETURNS TO OFFSET DEMANDS -- FINAL

USING SERVICEABLE RETURNS TO OFFSET DEMANDS -- FINAL

Modified Percent Errors (Both <=$200 and >$200)

(Average Ratios of Error to Old Year Demand)

Average Annual Number of Requisitons in 1981-82	Offset 0%	5%	10%	15%	20%	50%	100%
2.5-4	1.741	1.736	1.732	1.728	1.725	1.724	1.747
4.5-8	1.614	1.607	1.601	1.596	1.592	1.585	1.607
8.5-16	.987	.977	.969	.964	.960	.960	.985
16.5-32	.805	.791	.781	.773	.769	.765	.778
32.5-62	.753	.742	.734	.729	.727	.728	.743
62.5-122	.570	.553	.542	.535	.531	.530	.544
122.5 & More	.430	.412	.402	.398	.396	.395	.394

END

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